

Editorial

Are nanoparticles (NPs), solid or liquid? Does NP physics differ from those of larger aggregates? How and where do NPs form, do they agglomerate? How and how far do NPs travel? Are NPs inhalable, do NPs cross biological membranes reaching different organs of the body? NPs are made of what? Do they adsorb and transport chemicals? What is their impact on environmental processes, do they affect climate? Are NPs toxic? Do they interfere with intracellular processes, triggering cell responses such as oxidative stress, up- and down-regulation of genes, uncontrolled cell growth and mutations?

These are just some of the questions which we should have answered before starting the mass production of combustion engines which release NPs at large scale. Did you know that the current European and Swiss emission limit for NPs of 23–200 nm in diameter is 600 billion particles per kilometer. Thus, moving one such vehicle by one centimeter implies the release of 6 million nanoparticles. No wonder that traffic-affected air contains 40'000 NPs/cm³.

We inhale NPs with every breath but our knowledge on their effects is limited. One reason for this is the fact that we had no analytical tools to monitor NPs in exhaust, in the air and the environment.

This was a major challenge in the nineties, when the first edition of the ETH Nanoparticles Conference (NPC) was held in Zürich in 1997.^[1] It was the time when Switzerland started construction work on the longest railway tunnel, the NEAT, including 2 bores of 57 km and various shafts and tunnels with hundreds of workers exposed to diesel exhaust for time periods of >20 years (1993–2017).

It was the pioneering work of the late Hans-Christoph Siegmann of the aerosol physics group at the ETHZ to develop tools to detect NPs. Important contributions came from late the Ueli Matter and **Heinz Burtscher**, who will give a short introduction on NP physics. Together with **Oliver Bischof** and **Martin Fierz** he will highlight those properties that have been used to develop and commercialize instruments to measure NPs. The importance of carbonaceous nanoparticles will be presented by **Alejandro Keller** and coauthors. The presence of trillions (10¹²) of NPs in exhausts of internal combustion engines will be shown by **Jan Czerwinski** and coauthors for vehicles and machinery. **Jacinta Edebeli** and coauthors will demonstrate this for jet engines. A first particle number emission limit of 10¹² particles/kWh was established for construction machinery in Switzerland in 2009. In 2011, limits of 6x10¹¹ particles/km were set for diesel passenger cars and light-duty vehicles in Europe.

But it was obvious that efficient filter technology was urgently needed to comply with Swiss workplace regulations and with it a methodology was needed to test particle filters, determine filtration efficiencies, and assess risks of secondary poisoning. A consortium of filter manufacturers, authorities like the Swiss National Accident Insurance Fund (SUVA), the Federal Office for the Environment (FOEN, BAFU) and the research institutions ETH, Bern University of Applied Sciences (BFH), University of Applied Sciences and Arts Northwestern Switzerland (FHNW) and Swiss Federal Laboratories for Materials Science and Technology (Empa) started to assess benefits and risks of filter technologies. As a highly recognized expert in this field, founder of the NPC and the VERT Association of filter manufacturers, **Andreas Mayer** and coauthors will present important steps in filter development, which have become the major technology to detoxify combustion engines.

Filtration efficiencies >95% were achieved already with first-generation particle filters. It also became clear that soot and ash particles accumulate in filters to levels that require regeneration strategies. Catalytic combustion of soot with various metals such as iron, copper, cerium, potassium, platinum, and mixtures of them were developed. Iron and cerium-based systems were the first to be used on roads and in tunnels. In other words, the chemistry of NPs matters and the catalytic conversion of accumulated soot and ash in filters should not produce new pollutants, as discussed by **Norbert Heeb** and coauthors.

Among the known constituents of exhaust, genotoxic material is considered critical, especially at workplaces. The co-release of NPs and toxic compounds adsorbing on the large NP surfaces, is a major threat. Evidence was found that NPs act like shuttles or 'Trojan Horses', penetrating cell membranes of the alveoli, blood cells and placenta. This work was done with cell models of the human lung and placenta and is presented by **Cheryl Koh** and coauthors. **Marloes Eeftens** and coauthors will present results on epidemiological studies on NPs effects. Particle burdens of Swiss ambient air, air-borne NPs and the chemical transformation of precursors released to the atmosphere and processed during oxidative ageing and transport has been addressed recently in *CHIMIA*.^[2]

The leading role of Switzerland during the implementation of filter technologies, first at underground construction sites (NEAT), the establishment of NP limits for off road machinery, on road diesel vehicles, buses and trucks in Europe and jet engines cannot be underestimated. The establishment of a conference platform and an international network to discuss latest developments in nanoparticle research were important steps, too. The history of the NPC with now 28 editions and the 29th announced for May 31–June 3, 2026, the conference archive with >4500 contributions are testimonials of this fascinating journey on nanoparticle research in Switzerland.^[1]

PD Dr. Loretta Müller, Prof. Heinz Burtscher, Dr. Norbert Heeb

[1] ETH Nanoparticles Conference (NPC), <https://www.nanoparticles.ch>.

[2] C. Mohr, U. Baltensberger, *CHIMIA*, 2024, 78, 709, <https://doi.org/10.2533/chimia.2024.709>.

Cover image: The formulas represent the polycyclic aromatic hydrocarbons Benzo(a)pyrene, 1-Nitro-pyrene, 2,3,7,8-tetrachlorodibenzofuran and 2,3,7,8-tetrachlorodibenzodioxin, all highly toxic species in combustion exhaust. Adsorbed on particles they can cross biological barriers, which is called 'Trojan horse effect'. The blue sky with white contrails from aircraft indicates the importance of aeroplanes for combustion emissions. The keywords represent the different topics covered by this issue. The image was created by Norbert Heeb, he used pictures from Dr. A. Mayer (also author of an article in the NPC *Chimia* issue) and himself.

The *CHIMIA* Editorial is very grateful to PD Dr. Loretta Müller, Prof. Heinz Burtscher, and Dr. Norbert Heeb for their great efforts in organizing this issue on *Nanoparticle Research in Switzerland – From the Past to the Future* showcasing the approaches, research, and challenges in measuring NPs in the atmosphere and ways to combat the effects.



Loretta Müller



Heinz Burtscher



Norbert Heeb